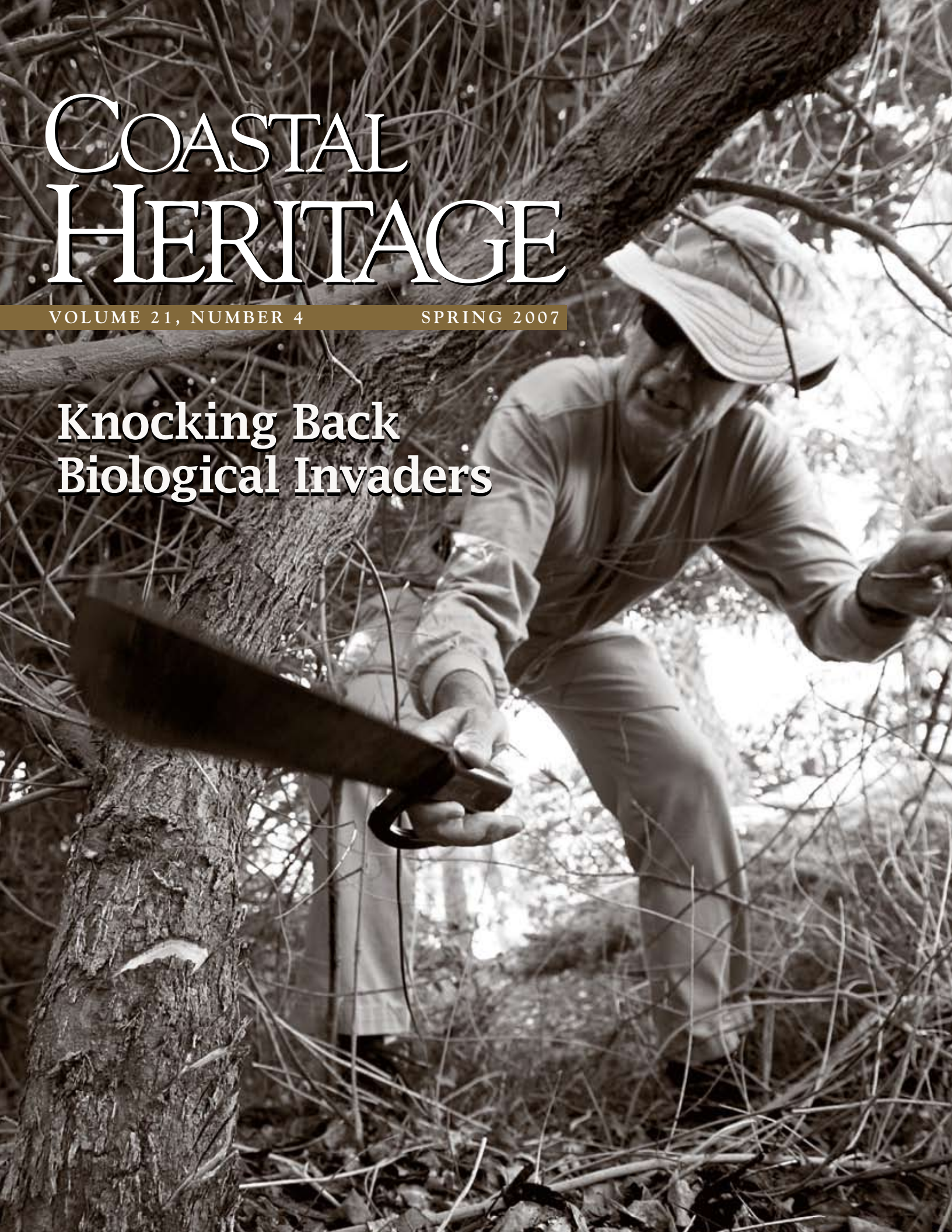
Coastal Heritage

VOLUME 21, NUMBER 4 SPRING 2007

Knocking Back Biological Invaders



CONTENTS

ON THE COVER: *Chuck Gresham, with support from the S.C. Sea Grant Consortium, is studying the impacts of beach vitex, a nuisance exotic, on native plants, and is knocking back these invaders along the shorefront at Debordieu in Georgetown County.* **PHOTO/WADE SPEES**

Sea Grant
S.C. Sea Grant Consortium

Coastal Heritage is a quarterly publication of the S.C. Sea Grant Consortium, a university-based network supporting research, education, and outreach to conserve coastal resources and enhance economic opportunity for the people of South Carolina. Comments regarding this or future issues of ***Coastal Heritage*** are welcomed at john.tibbetts@scseagrant.org. Subscriptions are free upon request by contacting:

S.C. Sea Grant Consortium
287 Meeting Street
Charleston, SC 29401
phone: (843) 953-2078
e-mail: Annette.Dunmeyer@scseagrant.org

Executive Director
M. Richard DeVoe

Director of Communications
Susan Ferris Hill

Editor
John H. Tibbetts

Art Director
Carl Turner

Board of Directors
The Consortium's Board of Directors is composed of the chief executive officers of its member institutions:

Dr. Andrew A. Sorensen, Chair
President, University of South Carolina

James F. Barker
President, Clemson University

John E. Frampton
Executive Director
S.C. Department of Natural Resources

Dr. Raymond S. Greenberg
President, Medical University of South Carolina

Dr. P. George Benson
President, College of Charleston

Dr. Andrew H. Hugine, Jr.
President, S.C. State University

Dr. Ronald R. Ingle
President, Coastal Carolina University

Lt. General John W. Rosa
President, The Citadel

CAUGHT IN THE ACT. *In October 2006, these juvenile green mussels, biological pests originally from Asia, were found clogging inlet pipes that feed fish-culture tanks at the S.C. Department of Natural Resources on James Island.*
PHOTO/WADE SPEES

Knocking Back Biological Invaders

By John H. Tibbetts

"They're here," David Knott said to himself when a colleague brought in some green shells for his inspection. The shells belong to the green mussel, a saltwater pest that's invaded U.S. estuaries, first in Florida, thousands of miles from its Asian native habitat in coastal waters along the Persian Gulf to Hong Kong.

"In places where the Asian green mussel is established," says Knott, "it's the saltwater functional equivalent of the zebra mussel." The notorious zebra mussel (*Dreissena polymorpha*), a freshwater nuisance, can't be eradicated region-wide and costs large sums to manage.

Knott, a marine biologist with the Marine Resources Research Institute (MRRI) at the S.C. Department of Natural Resources, has tracked sightings of the green mussel (*Perna viridis*) in South Carolina, as have other scientists in Georgia and Florida.

Sometime in the 1990s, oceangoing cargo ships carried the mussel to the Caribbean Sea and then Tampa Bay as a stowaway in ballast-water tanks, which provide stability for ships at sea. When a giant ship is empty of cargo and lacks ballast, it bobs in the ocean, and high waves can break it apart. So, before leaving port, the captain adds huge amounts of water to the ship's ballast tanks.

These tanks are aquariums in motion on the high seas. Ballast water, if untreated, is abundant with small fish, jellyfish, clams, mussels, crabs, shrimp, algae, bacteria, and viruses, which can survive a trip lasting weeks. Every day, at least 5,000 aquatic species ride in ballast-water tanks around the world. Virtually every estuarine species can be carried as eggs, cysts, or larvae—or as juveniles or adults—from harbor to harbor.

When a ship arrives in a port and releases ballast water from another estuary, creatures can be flushed out, too. If the new habitat is similar to the old one, an exotic species can get established and can become a costly pest.

Green mussels spawn early and grow large—hand-size at full maturity. In west Florida, they have proliferated rapidly in dense, heavy layers on marine facilities and boats. Their accumulated weight has sunk navigational buoys and floating docks. Colonies have stopped up water intakes in Florida power plants, says Knott, "like a coronary blockage that restricts the flow," requiring expensive treatments. And the animal is growing in great abundance in intertidal oyster beds in west Florida, smothering oysters.

Extreme disturbance encourages exotics

Why do some exotic species go bad? Why do they become pests? To survive, an introduced species needs an accommodating blend of climate, food supply, soil or water type, and a relative lack of natural diseases, parasites, competitors, and predators. Few non-natives can find all their needs in an unfamiliar environment.

The overwhelming majority of introduced species probably don't survive long enough to establish reproducing populations. When an alien creature arrives in a new place, it usually dies. It fails to compete against natives for food, or it serves as prey for predators.

Yet some exotics gain a foothold, reproduce, and eventually take over. Many biologists think that extreme disturbance—a dramatic change in the ecosystem—frequently offers exotic species the very ingredients they need.

"It's the disturbance that creates a new habitat," says Daniel Simberloff, an ecologist at the University of Tennessee. Construction of a road or house can "stir up the soil and liberate nutrients—phosphorus and nitrogen—in great amounts. There are a number of invasive plants that are adapted to use nutrient-rich sites, and many of the native species are not. When you create a new environment, it should not be surprising that you have different species that are suited to it."

Excess nutrients—from fertilizers, sewage-treatment plants, and other sources—are a first-order problem in estuaries. Nutrients pour into coastal areas, altering the composition of species in some locations.

The growth and expansion of *Phragmites australis*, an exotic plant, in freshwater environments near the South Carolina coast are probably encouraged at least in part by excess nutrients, says James T. Morris, a marine scientist and director of the University of South Carolina Belle W. Baruch Institute.

From Tampa Bay, the green mussel apparently hitchhiked in ballast water or on the hulls of barges and other vessels to Florida's east coast. In all likelihood, it naturally dispersed north up the Georgia shoreline and then to South Carolina, which was thought to be too cold for the animals.

In October 2006, Knott's colleague, Wallace Jenkins, found green mussels in pipes feeding Charleston Harbor water into Fort Johnson fish-culture tanks on James Island. Knott placed the specimens into the collection of the Southeastern Regional Taxonomic Center of the S.C. Department of Natural Resources. The center houses a collection of marine and estuarine animals from North Carolina to Florida.

"The green mussel is growing and spawning in South Carolina," says Knott. "The question is whether it can survive the winters here. South Carolina might be too far north for the animal to survive on a widespread basis. But it might be able to survive in other ways."

Some of the mussels could find refuges near industrial outflow pipes or in deeper water, where winter temperatures are warmer than on the surface. "That's probably how some of them hold on," says Loren Coen, an MRRI senior marine scientist. Some might prosper in lowcountry waters every spring and remain a pest until late fall. Or they might survive and spawn only during unusually warm coastal winters.

Knott, with support provided by the S.C. Sea Grant Consortium, is looking for the pest in the lowcountry on seawalls, bridge pilings, oyster beds, commercial marinas, floating docks, and elsewhere.

The green mussel is already an established biological invader in Florida, and because coastal waters are warming, it seems more likely that eventually the animal could become one here as well.

A biological invader is usually defined as a non-native species that grows out of control, causing economic damages or adversely affecting public or ecological health. In South Carolina, well-known invaders include kudzu, hydrilla, water hyacinth, the imported fire ant, and *Phragmites australis*, a freshwater wetland plant.

Today, there are more pathways than ever for aquatic species to spread, including trade in aquarium fish, seafood, live bait, and aquaculture products. Even so, ballast water is by far the major vector for aquatic nuisances entering U.S. estuaries. That's why effective management and treatment of ballast water is crucial to slowing additional pest invasions.

Research institutions, private firms, and government agencies have been working on ballast-water treatments that could help keep exotic creatures out of coastal waters. Treatment options include filtration and separation; sterilization by ozone, ultraviolet light, electric currents, or heat; and biocides to kill organisms.

A treatment method must destroy potential pests in gigantic quantities of ballast water carried by cargo ships, and it has to be cost-effective. It can't interfere with ship operations or pollute local estuaries. Today, each technology has limitations, and that's why many research programs are studying various combinations.

"The shipping industry has been trying to deal with the issue of ballast water for a number of years," says Byron Miller, spokesman for the S.C. State Ports Authority. "It's an international industry, and ballast water is a very serious topic. People have spent a lot of money trying to find long-term solutions."

POCKETBOOKS AND PUBLIC HEALTH

How are biological invaders—also known as invasive species—different from the thousands of non-native plants and animals that we find useful and beneficial?

An exotic species is a plant, animal, insect, or microorganism carried far from its historic home. Exotic species are also called "non-native" or "alien" or "non-indigenous"

TROUBLED WATERS.
David Knott, a marine biologist with the S.C. Department of Natural Resources, pries loose a non-native barnacle attached to a Sullivan's Island jetty. This nuisance barnacle can grow to be a 100 times heavier than native ones, potentially driving up anti-fouling costs for marine businesses, docks, and vessels.
PHOTO/WADE SPEES

species. In 1999, Cornell University researchers estimated that non-native invaders cost the nation $137 billion per year.

Many exotic species have proven beneficial. Cows, pigs, and chickens raised in North America are descendants of exotic species. Our pets—dogs and cats, for example—are non-natives. More than one out of five plant species in the United States is exotic. At least 6,600 species of foreign origin have become established in the United States and Canada since Europeans began exploring and colonizing North America.

While many exotics don't create obvious or immediate trouble in new environments, they can alter ecosystems without our realizing it. Perhaps 90 percent of all exotic species haven't been studied for their ecological impacts, says James T. Carlton, director of the Maritime Studies Program of Williams College-Mystic Seaport in Connecticut.

By contrast, invasive species like the zebra mussel are the ones that get public notice. Hardy, prolific, and adaptable, they are "weedy" creatures, becoming so abundant that they can drive down populations of natives, including rare species. The Cornell report estimates that more than 400 species, nearly half of the species on the U.S. endangered species list, are at risk at least in part because of non-natives.

"Where there used to be lots of different 'islands' of species, ecosystems are becoming more and more uniform," says Mark Hay, a Georgia Tech environmental biologist. "We continue to homogenize the biology of the world. We are moving species to new places at unprecedented rates because we move around so much. Humans are ultimately the ones lighting this fuse."

Biological invaders have damaged forests, rangelands, crops, recreational and historic sites, and water supplies. A number of invasive species—such as rats and mosquitoes—are dangerous vectors and reservoirs of human diseases such as malaria, yellow fever, and plague. In the aquatic realm, invaders can damage commercial and recreational fisheries.

Still, only a small percentage of exotic species turn into full-fledged biological invaders. An even smaller percentage of invaders become major pests that require public notice.

Successful invaders often have a competitive advantage over natives in the fight for survival. In many instances, an invader has left behind predators or pathogens that kept it in check back at home. Or evolution has provided the invader with weapons to push out competitors. Native species haven't had an opportunity to adapt naturally over time to these weapons, making them vulnerable to extinction.

For instance, beach vitex (*Vitex rotundifolia*), a non-native plant growing along some Carolina barrier islands, uses a chemical to discourage sea oats and other native species from getting established on the beachfront. The native plants, having evolved in different ecosystems from those of invaders, have no defense against the chemical and are being squeezed out.

If beach vitex continues to spread, sea oats and other native plant species eventually could be extirpated along portions of the East Coast, potentially harming the beach ecosystem and the sea turtles that nest there.

Some scientists and resource managers are trying to eliminate beach vitex from U.S. beaches—and that makes the plant an unusual case. Scientists rarely sound an alarm about a biological invader unless it has a strong likelihood to cause economic damage or affect public health, says Carlton. Beach vitex is primarily an ecological threat, likely to disrupt the beach environment.

Nationwide, there are many hundreds of invaders—tiny worms or crustaceans, for instance—in the marine and estuarine environment that the public doesn't know about. These species don't cause obvious, immediate harm to industry or human health but can alter the local ecology significantly. Scientists and resource managers pick their battles, calling attention usually only to invaders that could become major pests, affecting valuable resources.

In South Carolina, a multi-agency Aquatic Invasive Species Task Force is drafting a statewide management plan to prevent or reduce nuisances in public waters. The draft plan addresses primarily those species that are known to be pests in South Carolina or have a potential to become problems. The draft report also identifies some non-native aquatic species that have been found in South Carolina but have not become pests.

THE NORTHERLY PATHWAY

It seems clear that non-native species will increasingly arrive in the Carolinas from points south.

Almost 40 exotic invertebrate species have found homes in South Carolina's brackish or marine environments. At least six or seven of these species are native to the southern tip of Florida, the Keys, or elsewhere in the Caribbean, says Knott. The creatures were carried to South Carolina by ship fouling, aquaculture operations, ballast water, or by natural dispersal that coincides with a warming climate trend.

MARK HAY

"Where there used to be lots of different 'islands' of species, ecosystems are becoming more and more uniform. We continue to homogenize the biology of the world."

Several more of these invaders hitchhiked around the world from harbor to harbor, usually in ballast water, before they arrived in South Carolina. They probably first arrived in U.S. waters on the Florida Gulf coast, and then hitchhiked to the Florida Atlantic coast, which also provided suitable habitat. Finally, they moved up the coast to South Carolina, some carried by warm ocean currents, some carried inadvertently by shipping or by other means.

In December 2006, for example, five specimens of an exotic barnacle (*Megabalanus coccopoma*) were found at a marina in the Folly River near Charleston. Later, more specimens were found on a Sullivan's Island jetty.

Originally from the Pacific coast of North and South America, this species can grow to be 100 times heavier than native barnacles. The species was probably carried on ships' hulls, called "fouling," to the Gulf Coast by 2001. It hitchhiked to the Florida Atlantic coast and then moved farther north. If this barnacle gets established in South Carolina, it could drive up anti-fouling costs for maritime businesses. It probably arrived here via ballast water or by ship fouling.

For decades, South Florida has been a major hotspot of exotic species entering the United States. That region has a vigorous trade in aquarium fish, seafood, live bait, aquaculture products, and other pathways for non-natives. Moreover, it historically has been an "island-like" habitat, surrounded on three sides by salt water and on the fourth by frost.

Like other "islands," South Florida seems to have an impoverished number of native plant and animal species, which some experts say could make it more vulnerable to biological invasions.

The frost barrier in northern Florida is softening because of climate change. "Winters are becoming milder and coastal waters are warmer," says Carlton. "Lower latitude species are moving to higher latitudes. This is a trend that we're seeing all around the world." In the Northern Hemisphere, some species are moving northerly toward the North Pole, and in the Southern Hemisphere some species are moving southerly toward the South Pole.

MORE ARRIVING EVERY DAY

The zebra mussel was the first poster child of aquatic invasive species carried into the United States by modern global trade. Originally from the Black Sea, the zebra mussel was hauled across the ocean in ballast water, finding a home in Lake Erie in 1988.

Within a few years, the zebra mussel was carried throughout the Great Lakes and into rivers by barges,

SEEMINGLY INNOCENT. *Beach vitex can be an attractive plant, but it's a major nuisance on the shorefront. Sometimes called the "kudzu of the coast," this biological invader has been found from Ocracoke Island, N.C., to Edisto Beach, S.C.* **PHOTO/WADE SPEES**

Many invaders are overlooked

Hundreds of biological invaders have arrived in North America, but most of us know little or nothing about them.

For instance, the green porcelain crab (*Petrolisthes armatus*) is hugely abundant in South Carolina and Georgia oyster reefs. Historically, it lived in South America, Pacific Panama, the Caribbean, and the Gulf of Mexico. By the mid-1970s, it had arrived in the Florida Indian River system, which seemed to be the northern edge of its range. Then, in 1995, this tiny crab was found on the South Carolina coast, where its population has exploded.

The crabs can be as tiny as the head of a pin. "They are everywhere now," says David Knott, a marine biologist with the Marine Resources Research Institute (MRRI) of the S.C. Department of Natural Resources.

"This is a dramatic invasion," says Mark Hay, a Georgia Tech environmental biologist. "I'm unaware of anything like this. It's unimaginable how many there are." In one experiment on the Georgia coast, Hay and a graduate student, Amanda Hollebone, found an estimated 60,000 green porcelain crabs per square meter living on an experimental oyster reef during the summer.

Loren Coen, an MRRI senior marine scientist, has studied the porcelain crab with support from the S.C. Sea Grant Consortium. Coen found numbers as high as 20,000 per square meter in Charleston Harbor during the summer of 1999.

It's too early to say if green porcelain crabs are harming South Carolina oyster production. Still, the crabs are transforming relationships among predators and prey.

Hay says, "During the first four to eight weeks (after introduction), green porcelain crabs are having a significant effect on almost every species (on the oyster reef), sometimes positive, sometimes negative."

Once porcelain crabs invade, young oysters live longer. Perhaps native mud crabs are eating fewer young oysters because the native crabs are consuming green porcelain crabs instead. On the other hand, young oysters are growing more slowly after exotic crabs invade; the reasons why are unclear.

"The animal is probably of no serious concern because the animal is so small, and it's a filter-feeder and not a predator," says Coen. Even at very high densities, it probably wouldn't deplete sources of food for other species, he says.

Nevertheless, James T. Carlton, director of the Maritime Studies Program of Williams College-Mystic Seaport in Connecticut, says that it's very difficult to predict or estimate all of the ways that an exotic species will affect ecosystems. The cascading effects among various predators and prey are extremely complex, he says, "so when a new species arrives, it can take some years to really understand what it is really doing out there and whether we should be concerned."

and into smaller lakes via boat fouling as far southeast as Tennessee. It hasn't spread to South Carolina waterways, which apparently have limited amounts of calcium that the zebra mussel needs to build its shells.

During the 1980s and 1990s, the zebra mussel's mischief turned a spotlight on aquatic biological invaders.

"Until zebra mussels arrived, no one paid much attention to exotic nuisance species in marine environments," says Larry Harris, an ecologist at the University of New Hampshire. "Even today, many (agencies) have only started to monitor for invasive species in marine areas."

Nearly 20 years after a student on a field trip found the first zebra mussel in Lake Erie, it remains a nuisance in at least 20 states. Even so, some communities consider it yesterday's news. A more recent invader, the quagga mussel (*Dreissena bugensis*), probably introduced into U.S. waters in ballast water from Eastern Europe, is even more robust, out-competing the zebra mussel in Lakes Michigan and Huron, while causing similar problems.

"The zebra mussel is so 1990s to us" on Lake Erie, says Tom Henry, an environment writer for *The Toledo Blade*. More than 180 exotic species have historically arrived in the Great Lakes, and a new one is discovered about every eight months.

Once a non-native animal starts reproducing in an estuary, the ocean, or the Great Lakes, it becomes virtually impossible to eliminate the exotic entirely. Resource managers can only hope to keep these invasive species in check and control their damage.

Again, take zebra mussels. "They'll be here forever," says Jack Manno, executive director of the Great Lakes Research Consortium.

"You'll never get rid of zebra mussels totally," agrees Herb Gray, the Canadian Section Chair of the International Joint Commission, a bi-national body that resolves disputes concerning boundary waters between Canada and the United States. "But you don't have to throw up your hands either."

CAMOUFLAGED. ***Exotic species continue to slip into U.S. ports via ship ballast water, despite the shipping industry's efforts to stop them. Ballast-water tanks are aquariums in motion on the high seas, carrying exotics from port to port.*** **PHOTO/WADE SPEES**

Sue Haseltine, a chief scientist at the U.S. Geological Survey, points out that various tools and techniques have been used to knock back populations of aquatic invasive species to relatively small numbers. These include using pesticides, pheromones that interfere with the invaders' sex lives, and genetic manipulations.

Still, treating aquatic pests is a distant, second-best option. A far better strategy is prevention: keeping exotic species from arriving at all. Says Robert Costanza, an ecological economist at the University of Vermont, "Prevention is harder to sell to the public and less dramatic than treating invaders once they're here."

LOOPHOLES STILL ALLOW EXOTICS TO POUR IN

Creatures have been hitchhiking on ships to North America since Columbus' day.

Exotic hitchhikers have always been with us. But with increased global trade and travel, people are far more mobile today, and we carry non-native species with us around the world. Says Knott, "A greater proportion of ballast species can survive in tanks now because travel time for oceangoing ships is a fraction of what it used to be. Ships have also become much bigger, and they carry more ballast water. We're shipping more stuff, drawing in more water with a greater variety of species. As a result, we have more capacity to change the biotic component of our environment."

In 1990, Congress passed a law requiring ships to dump ballast water before they enter the Great Lakes. In 1996, Congress established similar but voluntary guidelines on ballast water for ships that enter all U.S. waters. But voluntary compliance was inadequate, according to the U.S. Coast Guard.

Now, federal law, administered by the U.S. Coast Guard, requires overseas ships steaming toward this country to exchange ballast water in the ocean farther than 200 miles from the U.S. shore. This process releases the estuarine species in the open ocean far from land, where they die. Meanwhile, seawater from the open ocean is poured into the tanks to ballast the ship. But this technique isn't perfect.

There are loopholes in U.S. law. If exchanging water at sea is dangerous because of inclement weather or high waves, ships don't have to comply. Also, about 80 percent of overseas ships arrive in the United States loaded with cargo, so they aren't officially carrying ballast water. The bottom of ballast tanks, however, often still contains water puddles and muck, which provide habitat for exotic species. Tanks that are considered empty can still hold 50,000 liters of water and a layer of sediment.

"There is a lot of evidence that these NOBOB (no-ballast-on-board) ships can be vectors" of exotic species, Carlton says. "They have a little bit of ballast or residual sediments that can be re-circulated in the tanks and be discharged at a later port."

That is, when a foreign ship drops its cargo at a U.S. port, it typically takes in ballast water, which can provide a temporary refuge for species living in muck or water on the tank bottom. When the ship steams off to another U.S. port to pick up cargo, ballast water can be legally discharged there, along with the non-native creatures.

Between two ports in the United States, then, a ship doesn't have to

Red lionfish invade deep-water reefs

PHOTO/S.C. DEPARTMENT OF NATURAL RESOURCES

The red lionfish (*Pterois volitans*), an exotic species from the Asian Pacific Rim, has found a new home in deep-water reefs from North Carolina to Florida.

"Reports from divers say that lionfish are very common," says David Wyanski, a scientist at the S.C. Department of Natural Resources' Marine Resources Research Institute (MRRI).

During two weeks in 2002, Wyanski and other MRRI scientists used submersibles to investigate deepwater reefs 40 to 50 miles offshore from St. Augustine, Florida, to the South Carolina-North Carolina border. "On a number of occasions you'd see three or four lionfish in your view, and the visibility is only about 30 feet or so."

Red lionfish are reproducing off the North Carolina coast, and scientists are worried that this population could expand significantly, consuming or out-competing commercially important reef fish. The red lionfish has no known predators. According to National Oceanic and Atmospheric Administration (NOAA) scientists, individual red lionfish seem to be growing larger more quickly than native fish.

When touched, lionfish can give a nasty sting from venomous spines. The sting isn't lethal to humans but is extremely painful, and it might explain why the lionfish doesn't have natural predators in the region.

Overfishing of snapper-grouper reef species has driven down those populations for decades, perhaps allowing red lionfish to flourish in their ecological niche. The grouper-snapper fishery is the most economically valuable finfish resource in the region.

Now, red lionfish are eating juvenile reef fish, especially juvenile sea bass and grouper. Lionfish could now be competing with adult groupers, which also eat sea bass, for food.

"We're concerned about a shift in the fish community, about the lionfish out-competing natives for resources, reducing the population of economically important fish," says Wyanski.

Some red lionfish likely got released from an aquarium in south Florida during Hurricane Andrew in 1992. The aquarium trade is a common pathway for aquatic nuisances.

exchange its ballast water at sea. So an exotic species from Asia or Europe that's become established in Tampa Bay or Mobile Bay, for instance, can be carried directly to Charleston harbor in ballast water and released here.

It's clear that a parade of exotics is continuing to enter U.S. ports via ballast water and other pathways, scientists say. In San Francisco Bay, a new species successfully invades every 14 weeks. To date, more than 250 aquatic biological invaders have become established there.

To understand the scale of the problem, consider the size of today's international merchant fleet and the ballast water it carries:

- Nearly 90 percent of global trade is by sea, involving a fleet of 45,000 oceangoing merchant ships, many of them gigantic container ships.
- About three to five billion tons of ballast water is transferred each year from international port to port, according to the Global Ballast Water Management Programme of the International Maritime Organization. A similar volume might also be transferred between ports just within the United States each year.
- The cargo volume that the United States alone handles—about two billion tons annually—will double over the next 15 years, according to the American Association of Port Authorities.

WHO'S IN CHARGE?

A federal court and state legislatures are applying pressure on the U.S. government to adopt tighter national treatment standards for ballast water on all ships entering U.S. waters.

One U.S. state—Michigan—is already regulating ballast water, using standards that are different from those of the federal government.

On Jan. 1, 2007, Michigan enacted a law that requires all ships that have floated on salt water and have ballast tanks and then expect to enter Michigan ports to prove that they will not discharge any ballast; or if they do

discharge, the ships must use one of four state-approved technologies to treat aquatic life in ballast tanks to prevent the escape of organisms.

Lawmakers in Minnesota, Wisconsin, and Indiana are considering establishing similar state standards.

In September 2006, California Gov. Arnold Schwarzenegger signed legislation that directs the state Lands Commission to create ballast water standards and have discharges completely species-free by 2020.

In 2004, the International Maritime Organization issued its own ballast-water guidelines, which are voluntary and too weak, experts say, to be effective for use in the United States. Even so, there is growing political pressure to establish tougher international rules.

The U.S. government's standards are also being challenged in court. In 1999, the conservation groups Northwest Environmental Advocates, The Ocean Conservancy, and Baykeeper sued the EPA to end the shipping industry's Clean Water Act exemption on ballast water. The EPA had exempted itself from regulating the shipping industry under the Clean Water Act for discharges that are "incidental to the normal operation of a vessel." The Great Lakes states of Wisconsin, Michigan, Illinois, Minnesota, New York, and Pennsylvania later joined the suit.

The nation's management of ballast water isn't working, according to U.S. District Judge Susan Illston. In September 2006, the Northern California federal judge issued a landmark ruling, giving the EPA two years to start regulating the discharge of ballast water from ships. For the first time, ballast water is to be regulated as a biological pollutant, if the ruling stands.

Unless overturned on appeal, Illston's ruling requires EPA to establish treatment standards to clean ballast water in all ships across the country.

"There is no dispute that invasive species have been, and continue to be, introduced into the marine ecosystems of this country through ballast water discharges," Illston wrote in her 21-page ruling. "There is also no dispute over the consequences that their introduction can have on the environment."

Judge Illston gave the EPA until Sept. 30, 2008, to end its ballast water exemption for the shipping industry. Her ruling, she wrote, will be effective nationwide, unless the EPA successfully appeals.

The shipping industry would have to develop or accept a technology to decontaminate ballast tanks without creating other pollution problems for estuaries. The EPA, moreover, would have to set standards that will certify ballast tanks as "clean."

But the "EPA must only apply the 'best available technology economically achievable'; it need not rush out to develop new pollution control technologies," Illston wrote in her judgment. In other words, the EPA will only have to begin dealing with the problem as best it can, based on current technologies.

Some are skeptical that new treatment methods would be an improvement on what is currently used.

"What we have today could already be the 'best available technology,' " says Miller of the S.C. State Ports Authority, referring to open-ocean exchange of ballast water. "I'm not sure what would be a better technology than what we have."

Indeed, it might take another 10 to 15 years, says Carlton, for scientists, the shipping industry, and policymakers to agree on which treatment methods are most effective and feasible for various ships and environmental conditions.

Meanwhile, state-by-state regulation is not practical over the long-term, he says. "I see folks eventually settling down to some kind of national or international regulatory framework."

The problem of ballast-water releases and exotic species isn't going away. Improving treatment technologies for ballast water is crucial to slowing introductions of exotic species into U.S. estuaries, says Carlton. "You have to get ahead of the game. It's really about prevention, about using the precautionary approach. Once a species arrives, and gets well-embedded in the environment, it's very hard to get it out again."

Reading and Web sites

S.C. Aquatic Invasive Species Task Force
www.dnr.sc.gov/water/envaff/aquatic/ais.htm

Burdick, Alan. *Out of Eden: An Odyssey of Ecological Invasion*. New York: Farrar, Straus & Giroux, 2005.

Carolinas Beach Vitex Task Force
www.beachvitex.org

Global Ballast Water Management Programme
globallast.imo.org

National Invasive Species Information Center
www.invasivespeciesinfo.gov

National Ballast Information Clearinghouse
invasions.si.edu/nbic

Sea Grant National Aquatic Nuisance Species Clearinghouse
www.aquaticinvaders.org

Sea Grant Nonindigenous Species
www.sgnis.org

Southeastern Regional Taxonomic Center
www.dnr.sc.gov/marine/sertc

Saving native dune plants from an oceanfront pest

If unchecked, an exotic shrub could become a major nuisance invader on the South Carolina coast, displacing native beach vegetation and potentially harming threatened sea turtles.

Originally from the Asian Pacific Rim and Hawaii, beach vitex (*Vitex rotundifolia*) was first planted in South Carolina in 1991 on Pawleys Island and Debordieu Beach, in Georgetown County. But it has become too successful, spreading along the shoreline.

Sometimes called the "kudzu of the coast," beach vitex has been found on beach dunes from Ocracoke Island, N.C., to Edisto Beach, S.C.

For several years after Hurricane Hugo, landscapers and property owners used the salt-tolerant plant to control beachfront erosion. Sea oats, which stabilize beach dunes, were in short supply at the time.

"Beach vitex was available at nurseries and from landscapers, and there was a lot of it," says Betsy Brabson, South Carolina coordinator of the Carolinas Beach Vitex Task Force and a sea turtle volunteer. The task force includes representatives from federal, state, and nonprofit agencies.

"Beach vitex produces a pretty blue flower in the spring," says S.C. Sea Grant Consortium researcher Chuck Gresham, a Clemson University coastal ecology and forest-science researcher. "In the summer, it has a nice, solid green look." But after studying its effect on native vegetation, Gresham concluded, "Beach vitex is not worth keeping."

The mature shrub spreads horizontally and vertically from a thick stem. It shades out native vegetation and produces a substance that reduces the soil's capacity to absorb water, thereby creating a poor seedbed for vitex's competitors. Its leaf litter also releases a waxy substance, creating a coating that reduces the soil's moisture absorption.

Beneath a beach vitex shrub, says Gresham, the "soil is as dry as a wood chip."

Vitex can cover entire dunes, runners growing on the upper beach to the high-tide line. The plant could potentially spread across beach dunes throughout the East Coast. Moreover, vitex dramatically alters the traditional aesthetics of the shore, perhaps affecting the tourism industry. Juvenile sea turtles, emerging from eggs buried on the upper beach, have become entangled in the vines.

The plant has not been officially listed as a federal noxious weed by the U.S. Department of Agriculture, and it can still be legally sold to property owners. Still, "nurseries on the South Carolina coast have recognized that they

EROSION CONTROL. ***Native dune plants stabilize beach dunes. Scientists are worried that invading beach vitex would displace native vegetation.*** **PHOTO/WADE SPEES**

are contributing to a problem if they continue to sell it," says Brabson. "The nurseries have been very cooperative."

Beach vitex apparently has not become a full-blown biological invader—yet.

The plant appears to be in an earlier stage of expansion on the South Carolina coast, says S.C. Sea Grant Consortium researcher Courtney Murren, a biologist at the College of Charleston.

Exotic species arrive and establish small populations in an unfamiliar ecosystem—if they're successful at all. Their numbers, at first, grow slowly but often persistently. Months, years, or even decades pass without a dramatic change. Then abruptly their population can grow out of control, becoming costly pests. "This is often a very quick switch" from the relatively slow-growing stage to full-blown invasiveness, says Murren.

What occurs during the period of slower population growth, which is called the "lag phase"? What turns on the invasiveness switch? Genetics? Environment? A combination of the two?

As part of the S.C. Sea Grant Consortium study, Murren is collaborating with Allan Strand, also a College of Charleston biologist, to better understand whether beach vitex is still in the lag phase or has recently left it. The researchers are studying the plant's genetic diversity, pollinators, and seed germinators. "If we can catch these things early," she says, "then we have a greater chance of stopping them."

In August 2006, the Carolinas Beach Vitex Task Force received a grant from the National Fish and Wildlife Foundation to eradicate the plant from at least 50 locations in Charleston, Georgetown, and Horry counties.

The $133,000 grant, administered by Clemson University at the Baruch Institute of Coastal Ecology and Forest Science, provides resources to remove the plant from the front beach and re-establish native vegetation.

Gresham is stretching grant funds to include 74 lots grouped on 22 South Carolina sites, all in developed coastal areas. Beach vitex is growing in another 44 locations—on uninhabited coastal islands and along developed beachfronts—that are not covered by the grant. "As we get additional funding, we'll address those other sites," says Gresham.

In November 2006, Gresham and Hal Drotor, a Clemson research technician, were applying the herbicide, Imazapyr (trade name "Habitat"), on a large patch of beach vitex on an oceanfront lot at Debordieu in Georgetown County.

After receiving permission from beachfront property owners, Clemson University personnel treated vitex plants by slashing the stems and slathering the herbicide into wounds.

By late spring, the plants should die and the herbicide will become inactive. Then researchers will remove the dead vitex stems and replant native sea oats and bitter panicum (*Panicum amarum*). The grant funding pays for all treatments, including re-planting.

"HACK AND SQUIRT." ***Sea Grant Consortium researcher Chuck Gresham slashes the stem of a beach vitex plant, a biological invader, before applying herbicide.*** **PHOTO/WADE SPEES**

EBBS & FLOWS

Working Waterways and Waterfronts 2007 Symposium

Norfolk, Virginia
May 9-11, 2007

Coastal communities and water-dependent industries face challenges of how to balance development pressures, recreational demands, and tourism with strategies for community development and business growth that are equitable and sustainable. Water-dependent enterprises—traditionally small businesses engaged in recreation, tourism, and marine trades—are at risk. As a result, land-use planners, politicians, and decision makers are not equipped to make reasonable decisions about waterfront development. For more information, visit www.wateraccess2007.com.

CNREP 2007: Challenges of Natural Resource Economics and Policy

New Orleans, Louisiana
May 20-23, 2007

This conference will provide an opportunity for government officials, resource managers, users, and residents to discuss approaches to restore coastal shellfish ecosystems through remediation and pollution abatement, habitat restoration, and stock enhancement. The conference will feature a series of invited keynote and panel presentations, case studies, and contributed oral and poster presentations. For more information, visit www.cnrep.lsu.edu.

Coastal Zone '07

Portland, Oregon
July 22-26, 2007

The biennial Coastal Zone conference, now in its fifteenth edition, is the largest international gathering of ocean and coastal management professionals in the world. Nearly 1,000 people attend, representing federal, state, and local governments, academia, nonprofit organizations, and private industry. The conference gives these attendees a platform to discuss the issues facing our world's coasts and oceans and a forum for discovering new strategies and solutions. For more information, visit www.csc.noaa.gov/cz.

ATTENTION SCHOOL TEACHERS! The S.C. Sea Grant Consortium has designed supplemental classroom resources for this and past issues of *Coastal Heritage* magazine. *Coastal Heritage Curriculum Connection*, written for both middle- and high-school students, is aligned with the South Carolina state standards for the appropriate grade levels. Includes standards-based inquiry questions to lead students through explorations of the topic discussed. *Curriculum Connection* is available on-line at www.scseagrant.org/education.

Subscriptions are free upon request by contacting: Annette.Dunmeyer@scseagrant.org

Sea Grant
S.C. Sea Grant Consortium
287 Meeting Street
Charleston, S.C. 29401

NON-PROFIT ORG
U.S. Postage Paid
Charleston, SC
PERMIT #248

Coastal Heritage is printed on recycled paper.
Web site: www.scseagrant.org